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Incidence and Predictors of Soft Tissue Injuries during Basic Combat Training

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Abstract: Strenuous exercise, such as military training, is known to demand a high degree of physical performance and to cause injuries. The present study aimed to (a) monitor the incidence of soft tissue injuries (blisters, contusions, and lacerations) among cadets during Basic Combat Training (BCT), and (b) identify possible risk factors for these injuries. Participants were 315 first-grade cadets (women, n = 28; men, n = 287), recruited from the Hellenic Army Academy. Seven weeks of BCT resulted in an overall cadet injury rate of 24.1% (n = 76) with 13.7% being injured one time, whereas 10.4% of participants were injured 2–6 times. The incidence of injuries was 2.9 soft tissue injuries per 1000 training hours. The logistic regression model using sex, being an athlete, nationality, weight, height, body mass index, and percentage of body fat (BF) to predict soft tissue injury was not statistically significant ($\chi^2_{(7)} = 5.315$, $p = 0.622$). The results of this study showed that BCT caused a large number of soft tissue injuries similar to the number reported for musculoskeletal injuries. In conclusion, following BCT, soft tissue injury characteristics (occurrence, severity, treatment) are similar to those applied in musculoskeletal injuries for Army cadets. However, risk factors such as sex, nationality, and BF have not been related to soft tissue injury prediction as previously shown for musculoskeletal injuries for the same sample group.

Keywords: blisters; body fat; body mass index; contusions; lacerations; military; sex

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1. Introduction

Basic combat training (BCT) is performed at the beginning of military life, lasts 12 weeks, and aims to transform trainees from civilians to soldiers [1,2]. In the case of military universities such as the Hellenic Army Academy, first-grade cadets participate in BCT [3–5]. BCT either for soldiers or cadets is a highly demanding period considering its training volume and intensity. Accordingly, it is not surprising that there is a high incidence of musculoskeletal injuries during this period [6], since it is well-known that the risk of injury is high in demanding physical activities and sports, e.g., combat sports athletes sustain one injury every 2.1 h of competition [7]. In the BCT of trainees, sex (women) and (increased) weight were injury risk factors [8]. In this population, an increased injury risk was related to either a high or low value of body mass index (BMI) [9]. Similarly, a survey showed that women and those with increased body fat percentage (BF) were at higher injury risk than men and those who were lean, respectively [10].

With regards to the prevalence of injuries in BCT, Jones and colleagues [11] followed soldiers for 12 weeks and observed an incidence of 37% to have at least one lower limb training-related injury, with the most common injuries being muscle strains, sprains, and overuse knee conditions. In military research, it has been suggested that an increased injury risk results from high volumes of running and low levels of physical activity [12]. During BCT in Norwegian conscripts, Heir and Glomsaker [13] reported that most of the injuries occurred in the lower limbs (63%) and included low back pain, overuse knee injuries, Achilles tendinitis, sprains of joint capsules or ligaments, and periostitis or compartment syndromes of the lower leg. The occurrence of injuries has been related to the intensity of training; for instance, injury rates ranged from 6 to 12 per 100 male recruits per month during basic training to as high as 30 per 100 per month for Naval Special Warfare training [14].

Although the abovementioned studies improved our understanding of musculoskeletal injuries in the army, less information existed on soft tissue injuries. Particularly, soft tissue injuries have not been studied in the BCT of cadets and no data concerned the region of Balkan. The knowledge about the incidence of soft tissue injuries would be of practical significance considering the role of BCT in the military training of cadets and the associated human and economic cost of injuries, and the loss of training time [15,16]. With regards to the economic cost, an analysis of USA Army trainees in 2017 showed a total direct medical cost of treating musculoskeletal injuries at ~$15M [17]. Moreover, identifying risk factors is crucial for injury prevention in BCT [18]. Therefore, the present study aimed to examine (a) the incidence of soft tissue injuries during BCT in cadets and (b) the role of sex, nationality, anthropometric characteristics, and BF.

2. Materials and Methods

2.1. Study Design and Participants

For the present research, a comparative prospective study design [19] was adopted, where the incidence of soft tissue injuries (blisters, contusions, and lacerations) among cadets was monitored during a 7-week BCT. Participants were 315 first-grade cadets (women, n = 28; men, n = 287; age 20.1 ± 1.3 years, mean ± standard deviation, height 1.78 ± 0.08 m, body mass, 76.7 ± 9.7 kg BMI 24.3 ± 2.4 kg·m^{-2} and BF 11.8 ± 4.6%) of the Hellenic Army Academy (that is the highest ranked military university in Greece, where graduates obtain the rank of second lieutenant after four years of studies). The study had ethical approval by the Ministry of Defense and all participants provided written informed consent. Participants had similar living conditions residing in similar barracks, eating from the same menu, and receiving the same opportunities for rest and sleep. The program of instruction was well established and all activities were carried out in platoon unit groups with little or no variation.

2.2. Physical Conditioning Program

BCT in the Hellenic Army Academy consisted of seven weeks of standardized military instruction (132 h) for both male and female cadets. The daily physical training program of BCT involved running (twice a day), strength training-calisthenics, marching, and military activities. Sprint agility exercises and non-tactical hikes were also performed once a week. All exercises were conducted in cadence and performed in the sequence listed. The program is analytically presented in Table 1.

Table 1. Training program overview during Basic Combat Training.

<table>
<tr><th>Activity</th><th>Duration</th><th>Special Notes</th><th>Frequency</th></tr>
<tr><td>Stretching; shoulder, chest, groin, thigh, hamstring, calf</td><td>10 min</td><td>4 × 12 reps in ballistic form</td><td rowspan="5">Daily</td></tr>
<tr><td>Intense running</td><td>10 min</td><td>70–80% of VO_2max 1–3 km distance</td></tr>
<tr><td>Various forms of push-ups sit-ups as well as callisthenic exercises; inverted crawls, hops, high jumps, supine bicycles, lunges</td><td>40 min</td><td></td></tr>
<tr><td>Light lunch and rest</td><td>60 min</td><td></td></tr>
<tr><td>Hiking with pack and equipment</td><td>60 min</td><td>2–5 km distance</td></tr>
</table>

Table 1. *Cont.*

Activity	Duration	Special Notes	Frequency
Lunch and sleep	120 min		
Stretching; shoulder, chest, groin, thigh, hamstring, calf	10 min	4 × 12 reps in ballistic form	
Low pace running	20 min	50–60% of VO_2max 3–5 km distance	
Military activities; prolonged standing in formation	60 min		
Military activities; Non-tactical hikes; bayonet training, arms practice	60 min		Once a week
Sprint/agility training and other occupational tasks	20 min	6–10 reps with 90 s rest	

Reps = repetitions; VO_2max = maximal oxygen uptake.

2.3. Registration of Injuries

Every injury for which a cadet had to consult a physician was registered, documented, and classified based on International Classification of Diseases-Ninth Revision (ICD-9) terminology. The information required for any injury was: characteristics (type, tissue, severity, and localization), conditions (BCT week, exercise mode), cadet characteristics (gender, nationality), treatment (rehabilitation details), and impact on BCT (lost training days). Supplementary hospitalization information was also obtained from the Military Hospital whenever the cadet had to be transferred outside the Academy. Recovery time was also recorded and defined as the period from the injury until BCT was resumed without any restrictions or pain. Current injuries were classified into two groups to calculate injury prevalence. Musculoskeletal injuries were defined as any self-reported muscle, tendon, bone, joint, or ligament injury; soft tissue injuries were defined as any injury that occurred to other tissues (skin, nails, etc.). Data on musculoskeletal injuries were published elsewhere [3–5], whereas the present study focused on soft tissue injuries.

2.4. Statistical and Data Analysis

Standard descriptive statistics (frequencies, percentages, means, and standard deviations) were performed on the data. The significance level for all analyses was set at alpha = 0.05. All statistical analyses were conducted using the Statistical Package for Social Sciences (SPSS) version 23.0 (SPSS, Chicago, IL, USA). Differences between injured and uninjured participants, and between normal- and overweight participants were examined using a *t*-test and chi-square test. The relationship of soft tissue injury with sex, being an athlete, nationality, weight, height, body mass index and BF was examined using a logistic regression model.

3. Results

Of the 315 cadets 76 of them (24%) were injured at least once during the 7 weeks of BCT. After classification, it was shown that the most frequently injured anatomical site was the ankle and foot (Table 2). Only a small percentage of all injuries were located in the upper extremities, while 77% were sustained in the lower extremities. Injury to the upper extremities was nearly equally distributed between the shoulder, arm, and fingers. Alternatively, in the lower extremities foot and ankle injuries represented more than the percentage of that represented hip/thigh, knee, and leg together. More than half of the injuries were diagnosed as blisters. Lacerations were also frequent, whilst, few injuries were diagnosed as contusions. The diagnoses of injuries covered a wide spectrum and are described in more detail in Table 2.

Table 2. Injury characteristics by proportion of incidence.

Anatomical Site		**Type**		**Severity**	
Back/Trunk	14.5% (11)	Lacerations	23.6% (18)	Grade 1	57.8% (44)
Shoulder/Arm	2.5% (2)	Contusions	15.7% (12)	Grade 2	21.0% (16)
Forearm/Hand	5.2% (4)	Abrasion/Blisters	60.5% (46)	Grade 3	14.4% (11)
Hip/Thigh	7.8% (6)			Grade 4	6.5% (5)
Knee	11.8% (9)				
Leg	10.5% (8)				
Ankle/Foot	47.3% (36)				
Week of BCT		**Time loss**			
1st	32.9% (25)	0 days		25.0% (19)	
2nd	28.9% (22)	1 day		15.7% (12)	
3rd	14.4% (11)	2 days		39.5% (30)	
4th	5.2% (4)	3 days		13.1% (10)	
5th	7.8% (6)	4 days or more		6.6% (5)	
6th	7.8% (6)				
7th	2.5% (2)				
Percentage and number of cadets in parentheses					

Seven weeks of BCT resulted in an overall cadet injury rate of 24.1% (n = 76) with 13.7% being injured one time, whereas 10.4% of participants were injured 2–6 times. In total, 122 soft tissue injuries were reported for 41,580 h (132 training hours × 315 cadets), i.e., 2.9 injuries per 1000 training hours. Among injured participants, more than half of participants reported a single injury, about one-third of participants had two injuries, whereas ~10% of participants had three or more injuries (Figure 1). With regards to the treatment of soft tissue injuries, the most prevalent was abstention from exercise followed by non-treatment, pharmaceutical treatment, and hospitalization. The logistic regression model using sex, being an athlete, nationality, weight, height, BMI, and percentage of BF to predict soft tissue injury was not statistically significant ($\chi^2_{(7)} = 5.315$, $p = 0.622$).

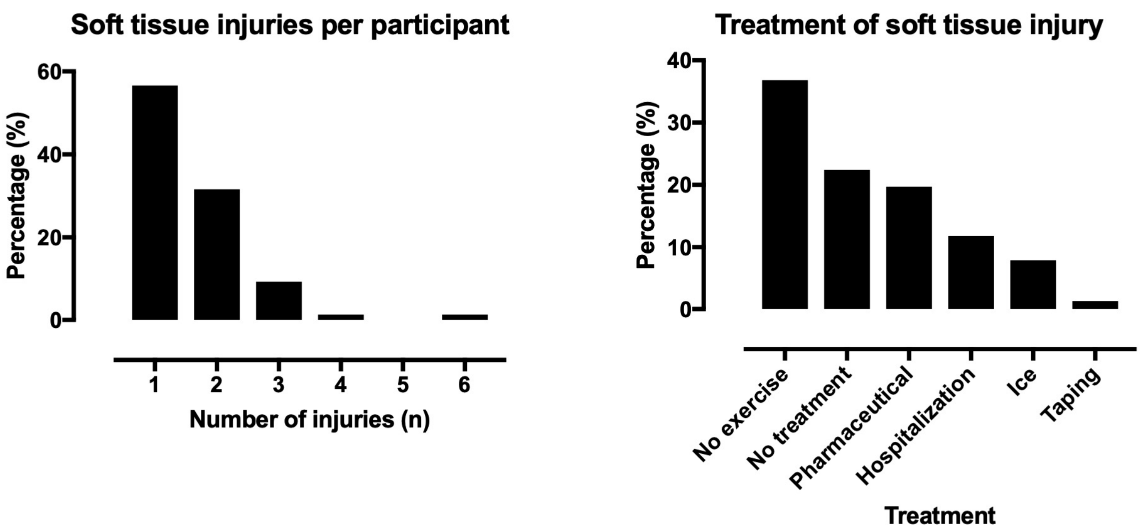

Figure 1. The number of soft tissue injuries per injured participant (**left**) and treatment (**right**).

Compared to their non-injured counterparts, the injured participants did not differ in terms of weight (−0.2 kg; −2.7, 2.3; mean difference, 95% confidence intervals, CI; p = 0.887), height (−0.01 m; 95% CI −0.03, 0.01; p = 0.349), BMI (+0.07 kg·m^{-2}; 95% CI −0.55, 0.68; p = 0.640) and BF (+0.3%; 95% CI −0.9, 1.5; p = 0.831) (Table 3). No association of being injured or non-injured was shown with nationality (χ^2 = 2.368, p = 0.124, φ = −0.087), sex (χ^2 = 0.332, p = 0.565, φ = 0.032), and athlete status (χ^2 = 0.620, p = 0.431, φ = −0.044).

Table 3. Differences between non-injured and injured participants.

Variable	Non-Injured (n = 239)	Injured (n = 76)	p
Weight (kg)	76.7 ± 9.6	76.5 ± 9.8	0.887
Height (m)	1.78 ± 0.08	1.77 ± 0.08	0.349
BMI (kg·m^{-2})	24.3 ± 2.4	24.4 ± 2.4	0.831
BF (%)	11.8 ± 4.5	12.0 ± 4.7	0.640
Nationality (Greek/Foreigners)	196/43	68/8	0.124
Sex (Female/Male)	219/20	68/8	0.355
Athlete (No/Yes)	195/44	65/11	0.274

Values are presented as mean ± SD; BMI = body mass index.

About one-third (32.7%) of participants were overweight (Table 4). Compared to their normal-weight peers, overweight participants were heavier (+12.3 kg; 95% CI 10.5, 14.1; p < 0.001) with higher BMI (+3.9 kg·m^{-2}; 95% CI 3.6, 4.3; p < 0.001) and BF (+5.6%; 95% CI 4.8, 6.5; p < 0.001). No difference between normal- and overweight participants was observed in height (0.00 m; −0.02, 0.02; p = 0.876). Being normal- or overweight was associated with nationality (χ^2 = 5.702, p = 0.017, φ = 0.135) with the percentage of overweight foreigners (47.1%) being higher than that of Greeks (29.9%). No association was shown of being normal- or overweight with injury occurrence (χ^2 = 0.270, p = 0.603, φ = −0.029), sex (χ^2 = 1.774, p = 0.183, φ = −0.075), or athlete status (χ^2 = 2.487, p = 0.115, φ = −0.089).

Table 4. Differences between normal- and over-weight participants.

Variable	Normal-Weight (n = 212)	Over-Weight (n = 103)	p
Weight (kg)	72.6 ± 7.7	84.9 ± 7.8	<0.001
Height (m)	1.78 ± 0.08	1.78 ± 0.07	0.876
BMI (kg·m^{-2})	23.1 ± 1.4	27.0 ± 1.6	<0.001
BF (%)	10.0 ± 3.7	15.6 ± 3.8	<0.001
Nationality (Greek/Foreigners)	185/27	79/24	0.017
Injury (No/Yes)	159/53	80/23	0.603
Sex (Female/Male)	190/22	97/6	0.183
Athlete (No/Yes)	170/42	90/13	0.115

Values are presented as mean ± SD; BMI = body mass index.

4. Discussion

The main findings of the present study were that during a 7-week BCT (a) about one-quarter of cadets sustained a soft tissue injury at least one time, (b) the occurrence of soft tissue injury could not be predicted by sex, athlete status, nationality, anthropometric characteristics, and BF, (c) no difference was observed between injured and non-injured cadets in their anthropometric characteristics, and (d) the occurrence of soft tissue injury was not associated with being normal- or overweight.

The first finding coincides with those recently reported by Schram et al. [20], where 21% of all serious personal injuries are attributed to soft tissue injuries in a combined (regular and reserve) group of Australian Army soldiers. In that study, soft tissue injuries were ranked as the second source of injury, after musculoskeletal injuries (32%) and before collated other injuries (16%). It is also worth mentioning that the most common anatomical site for soft tissue injuries was the back/trunk possibly due to the frequent participation in live-fire exercises (sprint and shooting), which cadets execute on rough terrain. In contrast, Navy recruits presented the highest number of soft tissue injuries in the finger/thumb, which is probably explained by the forceful entry via small hatches/doors within a vessel [21].

The present study also showed that the incidence of soft tissue injuries (~ one-quarter of cadets got injured, ~ three injuries per 1000 training hours) fell within the range of 0.1–6.0 soft tissue injuries per 1000 training hours during sports training [22]. Jones and colleagues [11] identified older age as a risk factor for injuries in BCT; however, an explanation that we did not confirm their finding might be the small age range of the present sample. With regards to the prediction of soft tissue injury by sex, athlete status, nationality, anthropometric characteristics, and BF, the prediction model was statistically non-significant. This finding was in disagreement with a previous study on predictors of musculoskeletal injuries, where female, BF, and Greek nationality could predict injury [4]. On the other hand, previous research by Hill et al. [23] identified previous musculoskeletal injuries (knee, ankle), deployment-service time, and advancing age as significant risk factors for soft tissue injuries. Those results were attributed to impaired joint resiliency and impact-absorbing capacity, which gradually decrease with age.

In the present study, the finding of no difference between injured and non-injured cadets in their anthropometric characteristics was in agreement with the logistic regression analysis. The occurrence of soft tissue injury that was examined in the present study (lacerations, contusions, and abrasion/blisters) was not associated with being normal or overweight. Alternatively, studies on musculoskeletal injuries showed that—compared to normal-weight soldiers—underweight, overweight, and obese soldiers had a higher risk of lower limb injury [24,25]. Also, in a very large sample of active duty soldiers (n > 650,000), obese soldiers had an increased risk of low back pain compared to their normal-weight peers [26]. Moreover, research on army trainees reported that the average BMI group had the lowest risk of training-related musculoskeletal injuries [9]. Regarding treatment data, for most of the injuries, no exercise/treatment was followed (59%) whilst, pharmaceutical agents were prescribed for 20% of the injuries. Although antimicrobial prophylaxis is crucial for preventing soft tissue infections, immediate antibiotics in addition to post-traumatic combat-related soft-tissue injuries showed that does not improve infectious outcomes [27].

A limitation of the study was that the sample comprised officer cadets; thus, caution would be needed to generalize the findings to other military populations such as army trainees, considering that incidence and risk factors of injuries might vary even among training camps [18]. Furthermore, it should be highlighted that BCT in the Hellenic Army Academy occurred in September and October with a temperature of ~25–30 °C, and this should be considered concerning the seasonal variation of injuries (i.e., the higher incidence in summer than in winter) [28]. Another confounding factor for the high frequency of soft tissue injuries might have been incomplete rehabilitation and subsequent reinjury, as military personnel with lesser injuries do not receive the highest priority by physical therapists based on the current military doctrine. Furthermore, gender-neutral physical standards are one of the reasons that various military occupational specialties are poorly staffed by women in most Armies worldwide. The same applies to the Hellenic Army Academy where women represent 10–15% of the entire population. Although this difference can potentially influence statistical power, it is a common practice in various Armies [29–31] to compare unbalanced men and women sample groups, when assessing the relationship between gender and injury across different military groups. Nonetheless, in the present study, both men and women presented similar injury occurrences (23.7% and 28.6%, respectively; no statistical difference), a finding that indicates the same injury pattern for both groups. The present study's novelty is that is the first known research to identify the incidence, treatment, and correlates of soft tissue injuries (lacerations, contusions, and abrasion/blisters) in Army cadets during BCT.

5. Conclusions

Following BCT soft tissue injury characteristics (occurrence, severity, treatment) are similar to those applied in musculoskeletal injuries for Army cadets. However, risk factors such as sex, nationality, and BF have not been related to soft tissue injury prediction as previously shown for musculoskeletal injuries for the same sample group.

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